Regression Using LSTM Networks

Evolutionary LSTM for Prediction of Aircraft Readiness

Oct 23, 2019

PyData

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Outline

- Prediction of Startup Time
- Regression Problems
- Process Pipeline
- LSTM Networks
- Evolutionary Approach
- Conclusion

Prediction of Startup Time (PSRT)

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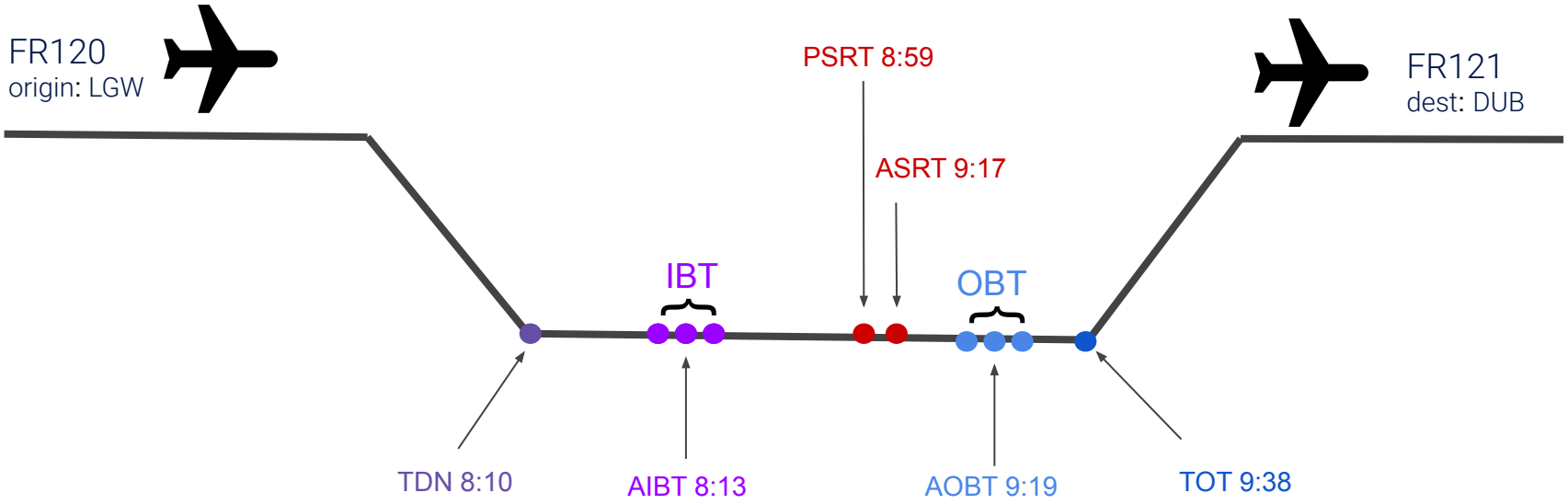
Turn Flight Scenario

TDN: touchdown time
IBT: In-block time
SRT: Start-up time
OBT: Off-block time
TOT: Take-off time



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The Problem

- Predict the startup time within an ± 5 minute-neighborhood of the actual startup time (regression problem)
- Prediction time is at in-block time (around 1-2 hrs before departure)
- The problem is complex, codomain is an unknown continuous space
- The aim is not to generalize well, but to target well each prediction
- Information from the past is important
- There is always randomness/ uncertainty!

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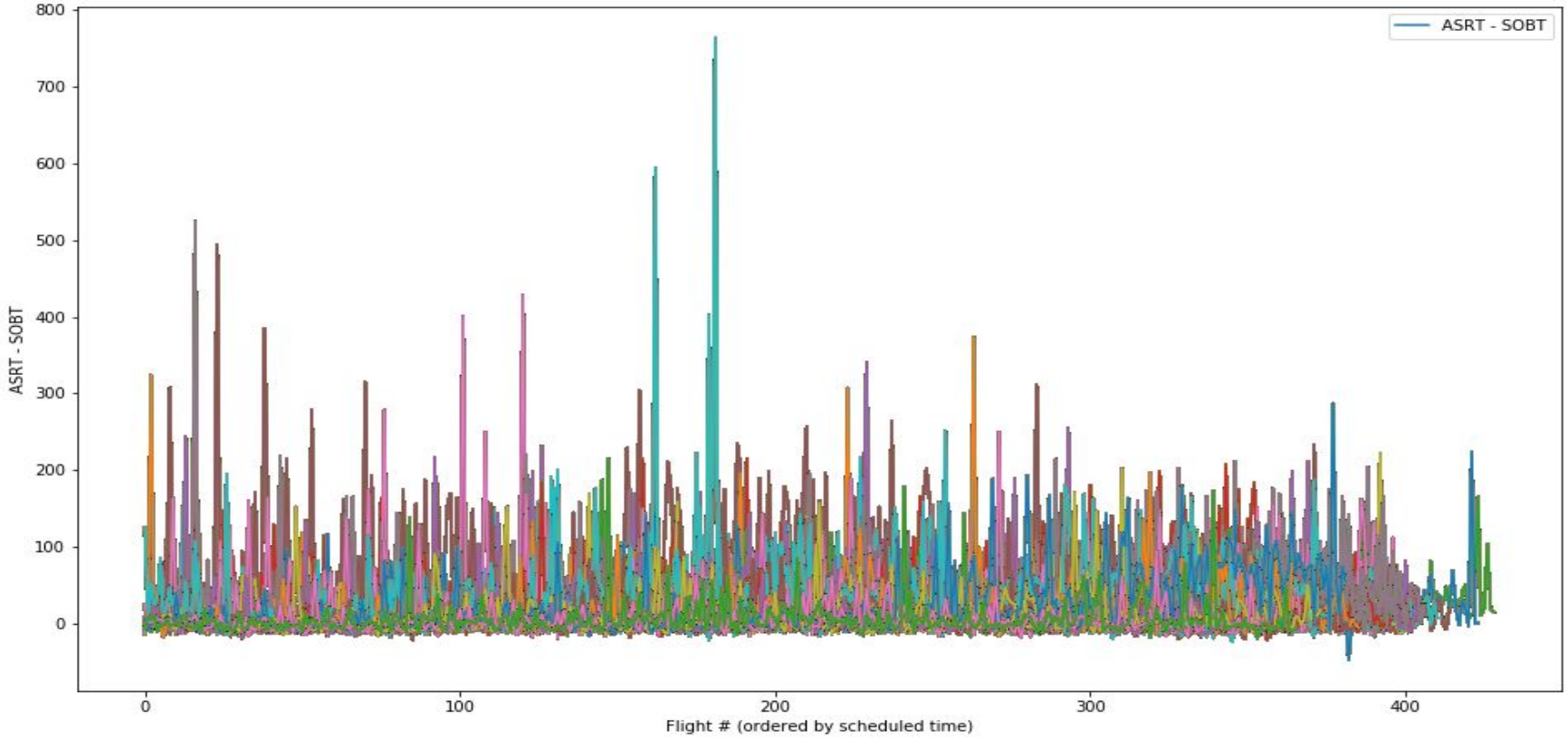
Data Distribution



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Regression Problems

What is a Regression Problem?

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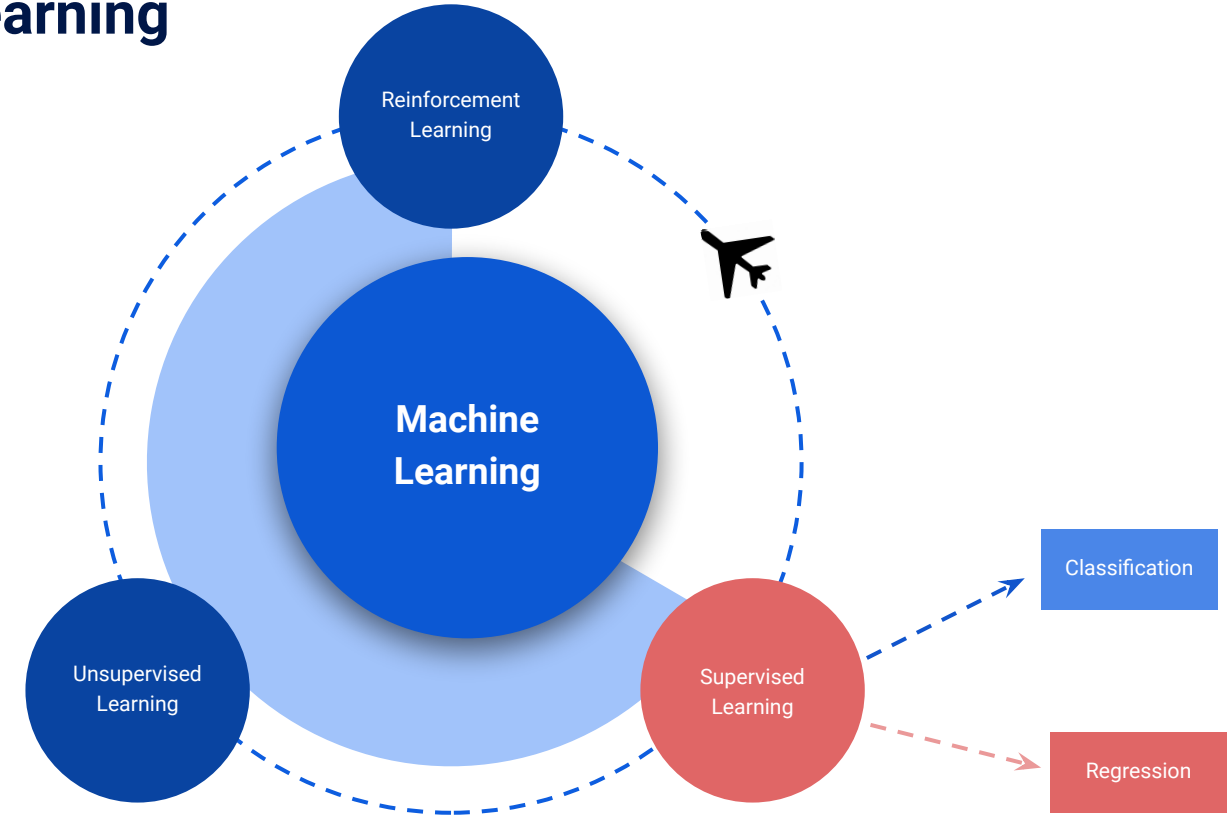
Machine Learning



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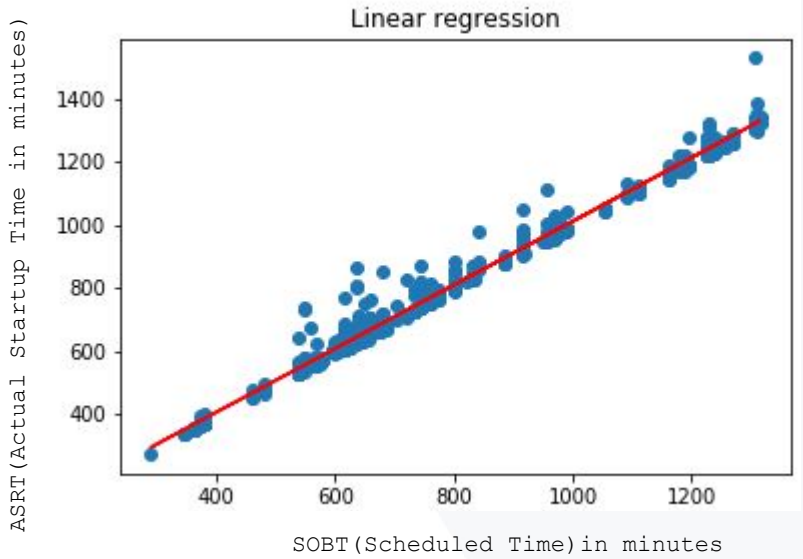
What is a regression problem?

- In supervised learning we try to learn the mapping function from the input variable (x) to the output variable (y), that is y = f(x).
- The goal is to approximate the mapping function (f) as accurately as possible such that for new input data (x), the output variable (y) for the dataset can be predicted.
- Regression algorithms attempt to estimate the mapping function (f)

from the input variables (x) to numerical or

continuous output variables (y)



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Other Regression Algorithms

- Polynomial Regression, Logistic Regression, Lasso Regression, etc.
- Support Vector Machines
- Decision Tree Regression
- Random Forest Regression
- K-Nearest Neighbours Algorithm
- Artificial Neural Network (ANN-backprop)
- Bayesian Inferences
- LSTM (Long-Short Term Memory Cells)
- etc.

Process Pipeline

How is a regression problem “solved”?

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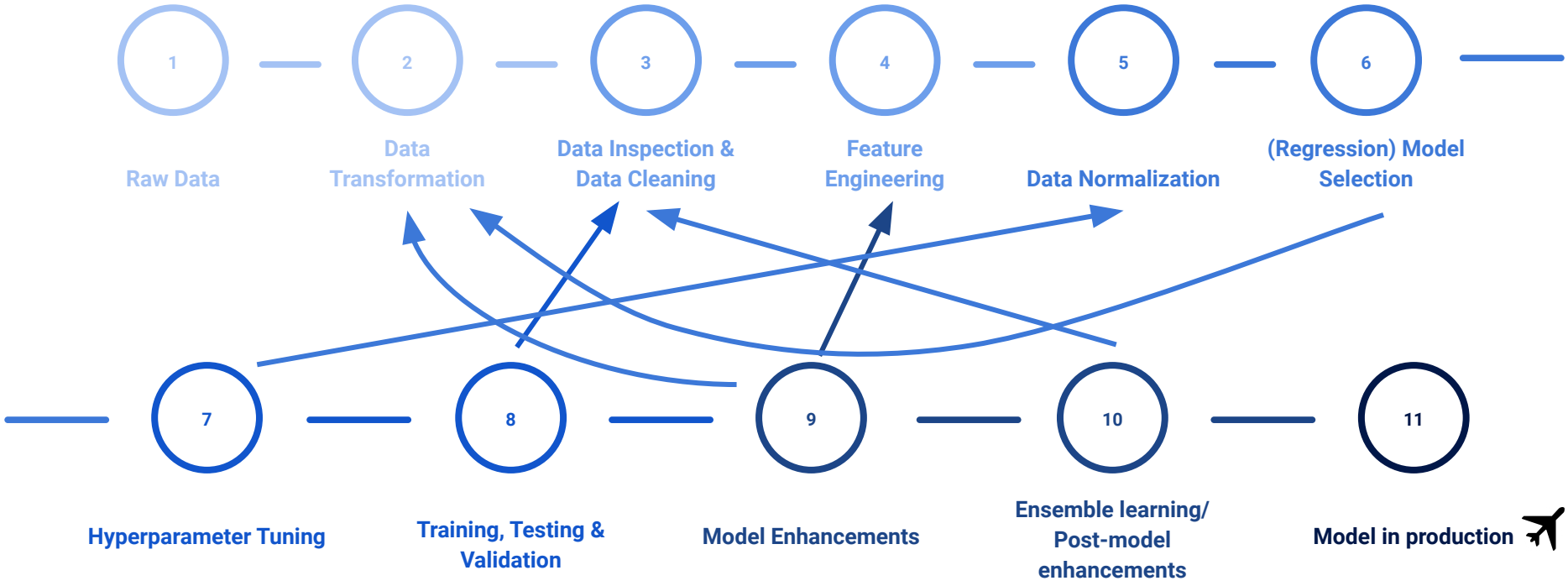
How Is a Regression Problem “Solved”?



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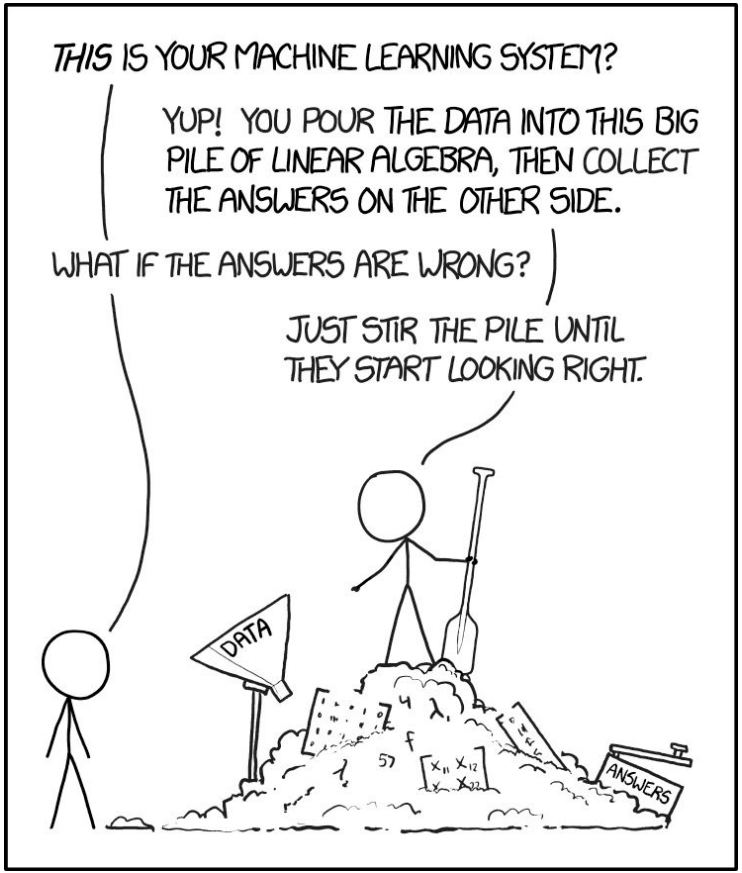
How Is a Regression Problem “Solved”?



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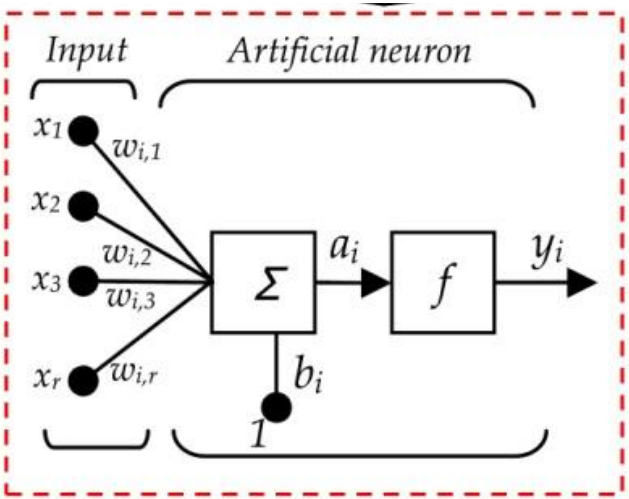
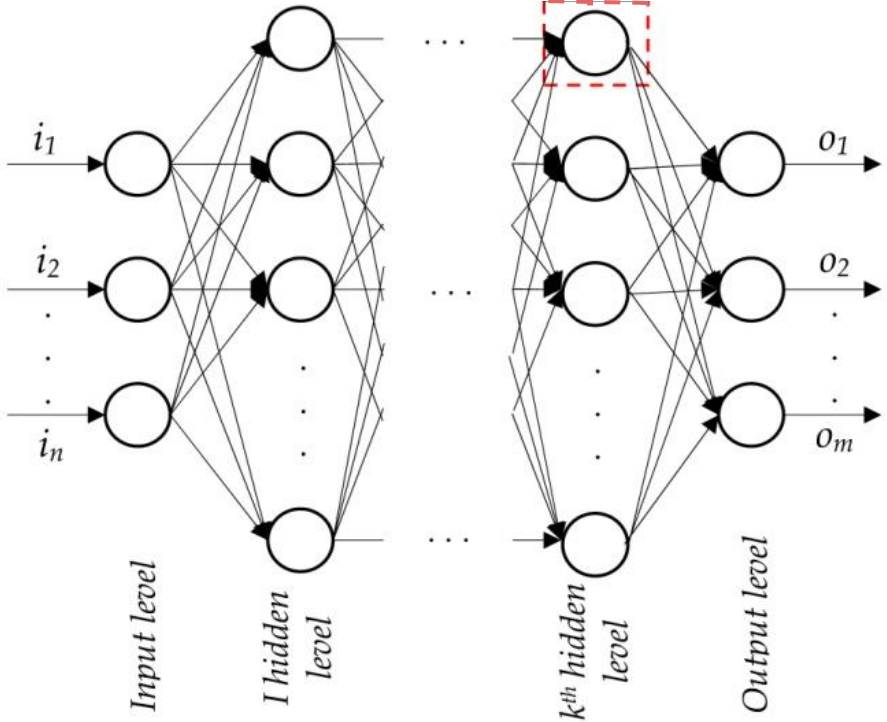
Regression Model: LSTM Networks

Artificial Neural Networks





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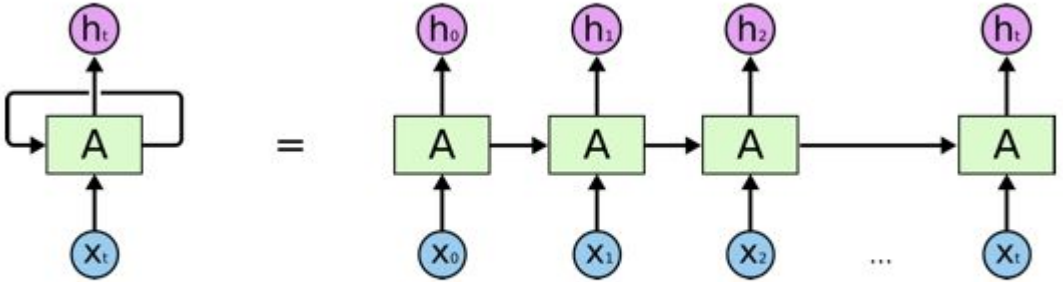
LSTM Networks

Long Short Term Memory is a recurrent artificial neural network architecture that uses loops to connect to earlier versions of the network, allowing information to persist.

Unlike standard feedforward neural networks, LSTM has loops (feedback connections).

It can process both single data points and entire sequences of data.

LSTM is applicable to tasks such as handwriting recognition, time-series problems or speech recognition.



An unrolled recurrent neural network.

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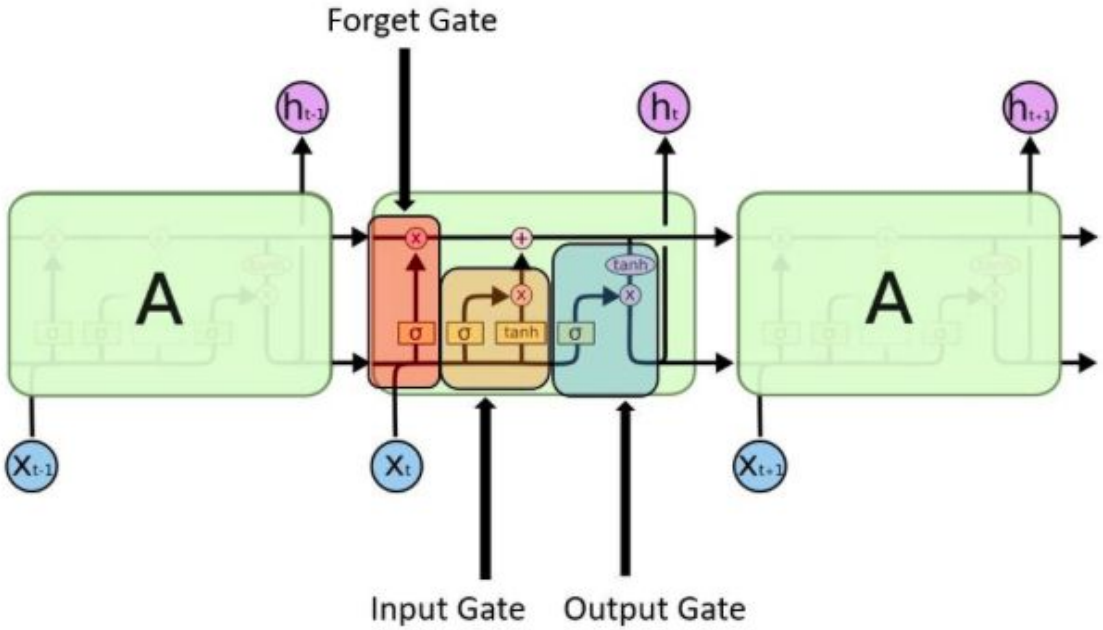
LSTM Networks

A common LSTM unit is composed of a cell, which has an **input gate**, an **output gate** and a **forget gate.**



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Hyperparameters

```
from keras.layers import LSTM
```

A series of hyperparameters to be fitted:

```
LSTM(units, activation='tanh', recurrent_activation='sigmoid', use_bias=True, kernel_initializer='glorot_uniform',
recurrent_initializer='orthogonal', bias_initializer='zeros', unit_forget_bias=True, kernel_regularizer=None,
recurrent_regularizer=None, bias_regularizer=None, activity_regularizer=None, kernel_constraint=None,
recurrent_constraint=None, bias_constraint=None, dropout=0.0, recurrent_dropout=0.0, implementation=2,
return_sequences=False, return_state=False, go_backwards=False, stateful=False, unroll=False)
```

+ Structure of the network (# of LSTM layers, # of dense layers)
+ The choice of a loss function (`from keras.losses import mean_squared_error, mean_absolute_error, mean_squared_logarithmic_error, mean_absolute_percentage_error, squared_hinge` etc.)
+ The choice of an optimizer (`from keras.optimizers import SGD, Adagrad, Adam, Adamax, Nadam,` etc.)

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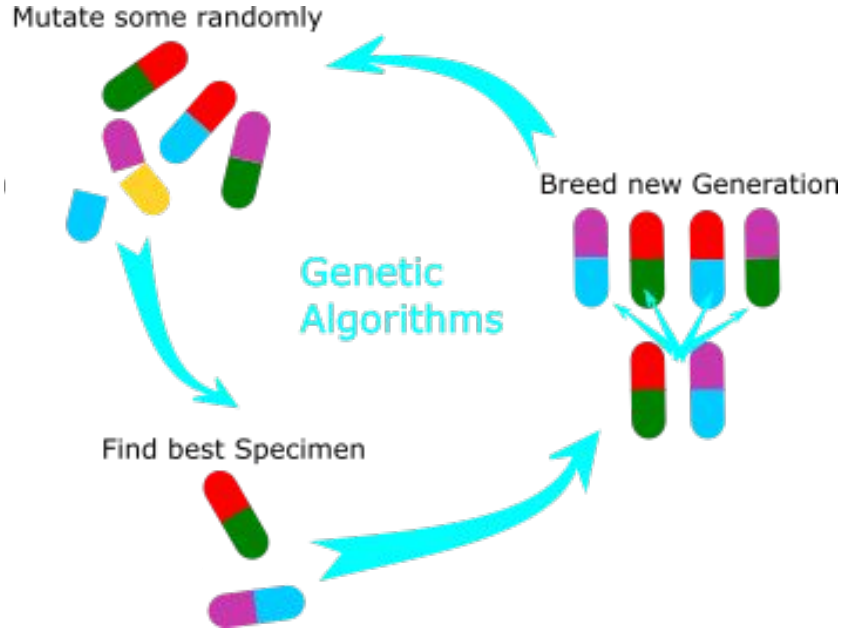
Post-enhancement: evolutionary approach

Evolutionary Enhancement

- Multiple LSTM models , all generalize well
- But we do not want to generalize, we want to predict well for every case
- Get a bag of models and mix until you get the best combination using Genetic algorithms



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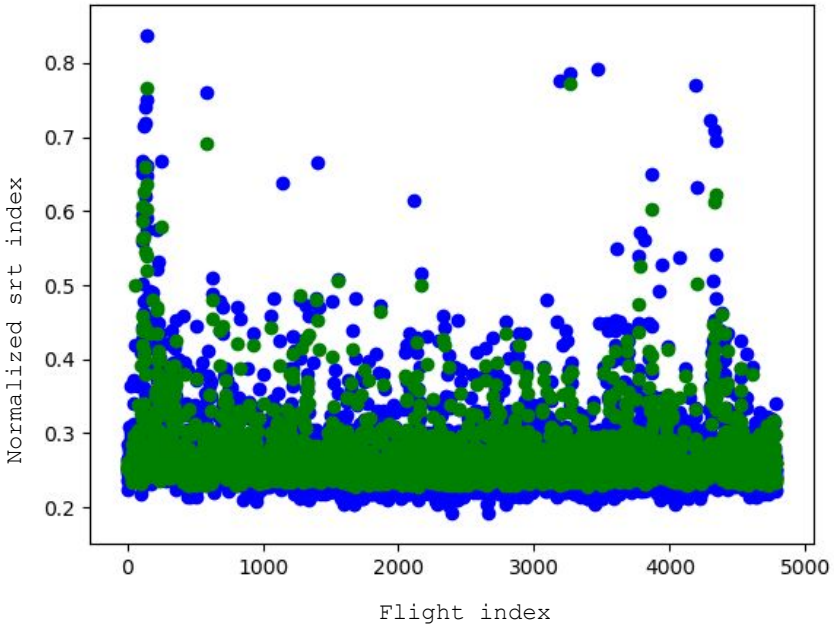
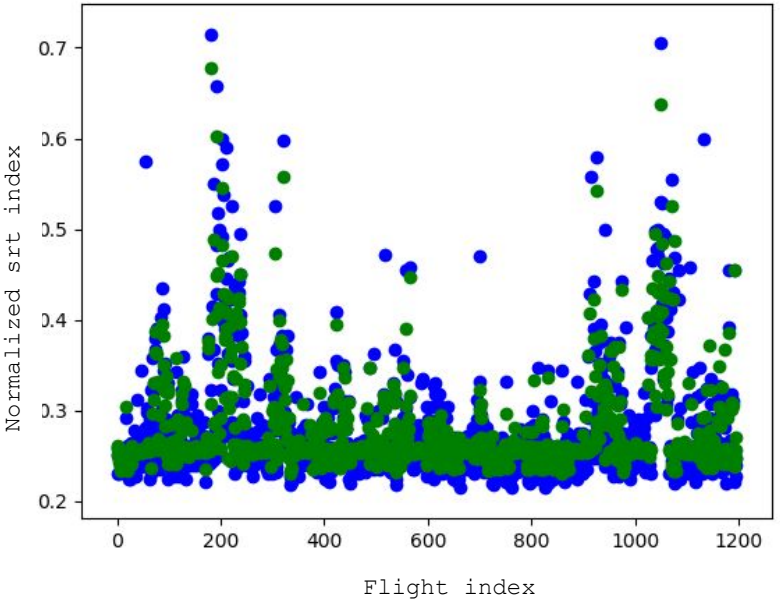
Results

Training an LSTM Model

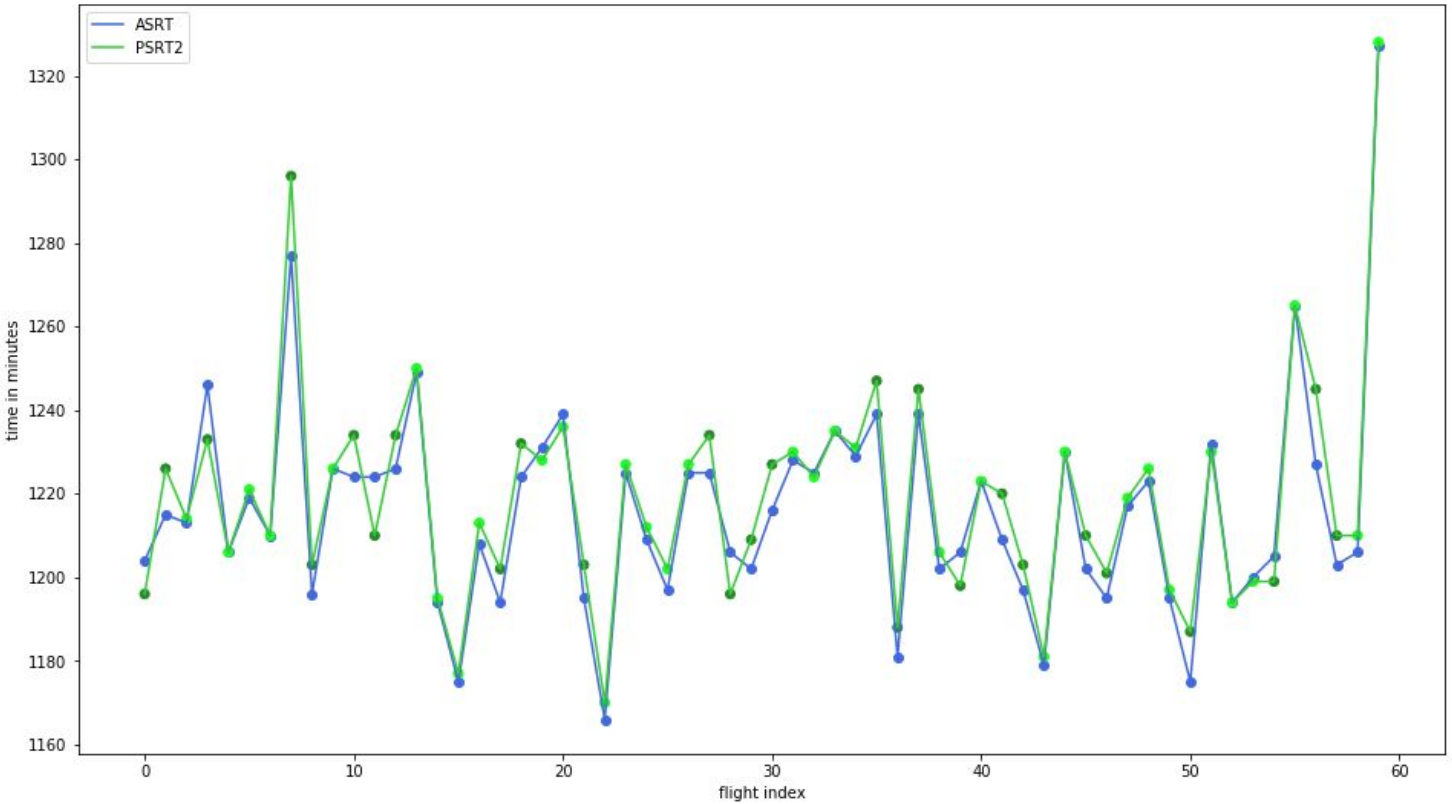
Training Data



Test Data



Performance



Performance is around 60-65% accuracy per day

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Conclusions

Conclusions & Future Direction

- Regression problems deal with predictions over a continuous space
- LSTM Networks generalize well and remember information from the past
- Our problem is complex, there is a lot of uncertainty ✈
- Post-enhancements improve accuracy of LSTMs
- Future direction: Online/Incremental learning

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Thank You!

Questions?

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